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ABSTRACT

This paper examines, from the perspective of the teacher, the relatively unimportant place of science in the elementary school curriculum. Two case studies of science education (of eight commissioned by the Science Council of Canada) provided data about science instruction in the K-6 elementary setting. Data were collected by observations made over a 5-month period. Particular efforts were made to collect observation and interview data relevant to how science is perceived by elementary teachers and to how science is actually presented to students. Factors appearing to affect teacher attitude and behavior in science teaching include background preparation in science, personal level of confidence, availability of materials and equipment, time constraints, the school curriculum, and patterns of communication and interaction among teachers within the school. These factors are illustrated with data provided by teachers in each of two schools, focusing on the thoughts and actions of the teachers with respect to science as they go about their daily lives in their schools. (Author/JN)

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ADD A LITTLE FRILL:
SCIENCE IN THE ELEMENTARY SCHOOL

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ADD A LITTLE FRILL: SCIENCE IN THE ELEMENTARY SCHOOL

Mary Schoeneberger and Thomas Russell

This is the story of science teaching in the two elementary schools that were among the eight schools studied intensively as part of the Science Council of Canada's Science and Education Study. One school is located in the Maritime region, the other in Ontario. During the fall of 1981 and the winter of 1982, the authors visited the schools frequently and worked closely with two teachers in each school. Our case study reports will become available late in 1983, when the set of eight case studies is published by the Science Council of Canada. Here we report highlights, themes, and broad issues relevant to the teaching of science at the elementary level. We begin with Schoeneberger's study.

Science at Seaward School

The place of science in the curriculum at Seaward School was summed up succinctly by one teacher when she said, "Well, your reading and maths are always your priorities and everything else--health, science, social studies--is lumped into what's left over." Lumped into what's left over. This proved to be a very revealing statement; observations over a four-month period at the school indicated that it was a very accurate one for most teachers, in regard to science. Here I examine some of the circumstances that placed science in the "left over" category, relatively unimportant in the curriculum.

Seaward School is located in a small town on the east coast of Canada and serves about 400 children from the town and the surrounding countryside. Fourteen classroom teachers and seven specialists taught grades kindergarten through seven. It was the teachers of K-6 who provided the general focus for my study, with two teachers (grade K-2 and grade 5) providing an in-depth focus. I was interested in uncovering how science came to be viewed by many teachers as a "left over" and what implications this had for science teaching.

We can begin by looking at the provincial guidelines that provide the basis for allocating time to individual subjects.

Grades 1, 2, and 3:

Language Arts (including Social Studies)	55%
Mathematics Education	15%
Science Education	10%
Physical and Health Education	10%
Music Education and Art Education	10%

Grades 4, 5, and 6:

Language Arts (including French)	40%
Mathematics Education	20%
Science Education	10%
Social Studies	10%
Physical and Health Education	10%
Music Education and Art Education	10%

Figure 1. Allocation of Instructional Time

Language arts and mathematics comprise the major part of the school program and thus are the mandated priorities for elementary schools in the province. It was not surprising, then, to find that the majority of classroom instruction was in these two curricular areas. The prescribed ten per cent allotment for science could mean up to two hours of science instruction each week for grades K-3 and up to two and one half hours of instruction for grades 4-6. At Seaward, however, only two teachers chose to allot such time to science; most classes received considerably less science instruction and some received little or none at all.

The two teachers (grades 5 and 6) who did teach science regularly to their classes were considered by their colleagues to be very knowledgeable in science. One, in particular, was considered an "expert," a label that set him apart from the others in regard to science teaching. The pervasive use of the word "expert" by many teachers, and the way it was used, suggested to me that if you knew something about science and were keen about it, it would be natural for you to be interested in it and to teach it regularly. Conversely, if you did not know much about science and were not very enthusiastic about it, you probably did not do much about it in the classroom and that, somehow, also was acceptable teacher behaviour. Several teachers indicated they felt guilty about the state of their science programs and the time they devoted to them. However, guilt alone did not seem to motivate them enough to change things. It appeared to be acceptable for teachers to teach science irregularly, a situation that had been the norm in the school for many years, particularly in grades K-3.

Mr. Millar, the principal, was well aware of the situation and told me that his school was not an anomaly in this regard. In his view, Seaward's situation with respect to the teaching of science is common to many elementary schools. As he said, "In a student's career in elementary school, if their luck is average, they are going to hit one teacher at least, maybe two, who is keen on science." He went on to say that if a teacher "concentrated on science" (that is, taught it regularly) the social studies part of the program probably "dragged its heels." However, he did not feel badly about this; he went on to say, "It probably evens out on the social studies side with another teacher."

Like the principal, the superintendent also was aware of the situation regarding science teaching. He required teachers to submit to him yearly plans in science as a way of reminding them that science was part of the curriculum, although he said he knew that teachers often did not teach to those plans and, in fact, a number of them did not do much at all in science. Although he was supportive of several attempts to improve science teaching, such as making science kits, none of these endeavours had any long-term effect.

Further up the administrative ladder there did not seem to be much concern for science either. According to the teachers, there was no leadership in science at the district level. The one curriculum consultant who was responsible for all areas of the curriculum concentrated on language arts and provided no assistance in science, a situation not uncommon across the province. One reason for this is that consultants generally do not have science training as part of their backgrounds. Only three of the 21 school districts in the province employ science consultants on a full-time or part-time basis. Thus the one provincial science consultant in the Department of Education is faced with the overwhelming task of providing expertise and assistance to teachers in the remainder of the province, in addition to the other considerable duties required of someone holding that position. (In September 1982, due to government financial restraint, operating budgets for provincial consultants were virtually eliminated, so now even that potential avenue of assistance has been curtailed significantly.)

Within the community that supports Seaward School, there also appeared to be little interest in or concern about science. The general consensus of the teachers at the school was that science was a "non-issue" to the community. Neither the principal nor

the teachers could recall any parent ever asking about, or even mentioning, the school science program. Over the years, in his dealings with school trustees, school boards, and the Home and School Association, the principal could not recall science ever being mentioned; neither, however, were subjects such as health, social studies or art. The primary concern was with "the basics." Mrs. Newman, who had been at the school for 16 years, described the community's concern for science in these words.

> I'm quite certain that you could go for a year without teaching science and there would be no comment. Parents see science as a little added frill, maybe. I don't think they see it being as important, for instance, as math is--that you know how to add, subtract, or that you are able to read.

All of these circumstances contributed to the message that science really was not that important in the total scheme of things at school.

In addition to the external messages that suggested the unimportance of science, there were other factors that contributed to its not being taught regularly. These were teacher related and management related. The most critical factor appeared to be the lack of confidence that many teachers expressed with regard to anything related to science but particularly towards teaching it. Most of them felt less comfortable teaching science than they did teaching any other subject. They attributed this to their weak backgrounds in science, their unfamiliarity with the content of the science program and the lack of structure provided by science curriculum materials.

For all but one teacher at Seaward School, academic backgrounds in science were minimal. The exception was Mr. Blake, the science "expert" who had majored in science and worked in science research prior to becoming a teacher. Of the others, only one had taken a biology course at university. Several others had taken some biology in high school and perhaps had studied chemistry, but no one had taken a physics course. A few had not taken science at all during their schooling. Several of the Teachers' College graduates had taken a science course during their training; however, none of them considered that course to have been of much value, particularly since it had been "so long ago."

Most teachers also had not taken a science methods course, because it was either not offered or not required as part of their preservice training, or because such courses were not available through continuing education or non-credit inservice courses. Even though some teachers indicated an interest in such a course, the opportunities for taking one were few, or non-existent.

In their interviews, many of the teachers' comments referred to their lack of familiarity with what they were supposed to teach the children. They felt they were "just one step ahead of the students." Despite the availablity of provincial guidelines and teachers' manuals (accompanying the STEM science program) outlining topics and concepts to be investigated, the teachers continued to feel insecure and inadequately prepared to teach science topics. These factors contributed to the maintainence of a low level of confidence among the teachers.

Another perceived barrier to teaching science was the lack of materials readily at hand. Although this did not stop Mr. Blake, who often went out and purchased what he needed to teach grade five science, it was cited by most of the other teachers as being a problem. The principal suggested that lack of preparation and long-term planning on the part of teachers was part of this problem. Apparently, orders were to be placed each spring for the following year and most teachers missed that deadline. Although there was some equipment scattered about the school, there was no system for keeping track of it, procuring it, or storing it. This lack of organization was a further source of irritation to some teachers.

In a room near the principal's office, I noticed a supply of science equipment (such as test tubes and racks and standard demonstration equipment) that had never been opened. Since the STEM science program was the primary resource for the school and required materials more commonly found in supermarkets and hardware stores, this traditional science equipment was of little value. Expendable materials could not be purchased under the capital equipment budget and money for such materials was more difficult to come by for spur-of-the-moment requests. Consequently, most teachers did not make the effort needed to secure the necessary supplies for their science classes.

Another factor that inhibited science teaching was the lack of sufficient time. According to the teachers, there just was not enough time to teach everything that was expected. Something had to suffer and often that was science. Over the years, more

and more had been added to the timetable but seldom had anything been taken away. Besides, some teachers felt they needed to spend time on the "basics" and that often cut into science time. Time out of teaching for assemblies, special activities and the like sometimes resulted in teachers using science time to make up for lost time in the basic subjects.

Some teachers, particularly those teaching grades K-3, justified the limited time they spent on science per se by saying they integrated it with other subjects and, thus, argued that more time was actually spent on science than might appear. I observed integration to mean primarily talking about topics that were science related rather than doing science. For example, a class might have read a story about frogs or a caterpillar. The information from the story was then used in a follow-up discussion in which the students talked about what they had learned and the teacher gave explanations and clarifications when appropriate. The teacher regarded this activity as integrating science and reading. Mrs. Leech, a grade one teacher, explained how she integrated reading and science.

> I tie it (science) in with the reading course. For example, Surprise, Surprise, the first reader of the series, starts off working with pets--the pet shop, going to buy a pet. So, instead of going from the STEM book on animal needs, I build from the reading course--like I integrate it. We start off with the types of animals you would have for a pet--tame animals and what they need--and then we go to wild animals and what their needs are. Really, they are getting it from the discussion. They are getting from their own home experience at this stage. About the only thing we did was that the children each brought in a picture of their dog, told us about it, wrote a story about their own dog and then the photograph went on a piece of paper with a story.

Aside from this type of integration and some reading and discussing of science textbook material, I was unable to document much science occurring in most K-3 classrooms. In Ms. Tanner's K-2 classroom, in which I observed regularly for the four-month period, integration was the primary teaching methodology. In addition to feeling somewhat inadequate with regard to teaching science, Ms. Tanner said there just was not enough time to teach everything that was mandated. She felt the most effective way to deal with this dilemma was to integrate subjects. It was

interesting to note, however, that while Ms. Tanner planned for language arts and mathematics, science, she said, "just happened." This was due in part to lack of time in which to plan. It also fit with Ms. Tanner's belief that science should stem from the spontaneous interests of the children. During my visits to her classroom, I observed only one lesson that began with science, and this involved observation of guinea pigs. This lesson branched into language development as well. Integration in Ms. Tanner's room usually centred around living things such as dinosaurs, guinea pigs, frogs, apples, and sunflowers. I never observed or heard mention of any physical science topics being part of the integration process. In fact, the physical sciences were generally absent from most classrooms between kindergarten and grade 4.

I was left with the general impression that many teachers considered science to consist of the learning of facts that could be obtained by reading and discussion, and that this could occur in a variety of contexts. In other words, science did not really require a separate block of time. The school principal was aware of the teachers' concept of integration in relation to science. He felt there were times when "integration" was used to "hide science" in another subject, as a way of rationalizing that science was actually being taught.

There was one exception to the type of integration I have been describing, and that occurred in Mr. Blake's grade 5 classroom. Mr. Blake was very interested in science, knew a lot about it, and felt very comfortable teaching it. He regularly integrated science and other subjects by beginning with a science activity and then extending it into language arts, mathematics, or social studies. For example, the classification skills learned in a unit on living things became the basis for classifying types of housing in social studies. Balance work led to the construction of home-made balances which then became the basis for a unit in mathematics dealing with masses of various objects. The results were then graphed and displayed around the room. The study of scientific names led to word study in language arts.

Mr. Blake was unique with respect to science teaching at Seaward in other ways as well. For him, science was central to his total grade 5 program. This was apparent the minute one stepped into his classroom. A variety of plants grew in different areas of the room, a pair of guinea pigs occupied a cardboard box in one corner, and an aquarium with guppies sat on a window sill. Children's science work was displayed about the room, and a single bird feather suspended from a string indicated

subtle changes in air currents in the room. In another corner, a computer was available for use by students. His cupboards stored common materials needed to teach the STEM program, as well as microscopes, insect collections, animal skeletons, and electrical supplies. Mr. Blake has a definite goal for his students' study of science.

> I want students to be curious. I want them to be investigative and to develop skills in it. I want them to be able to have the challenge of trying to figure out something from the facts they have. To me that's the basis of all education, and I think science is education, really. The goals I have for science are the goals I have for everything I do--having this sort of love of wanting to find out.

Mr. Blake operationalized his goals by attempting to provide an investigative environment for his students and by modelling inquiry in his teaching. During field work, for example, students were encouraged to examine and investigate. Mr. Blake's own investigative behaviour provided a model for the students, and his questions helped to focus their observations. For example, while digging in the forest floor, he put his fingers to his nose and said, "Smell your fingers. What can it tell you about the ground?" Walking through an area of pine and spruce trees and stumps, he stopped, commented, and then queried, "Thinning. Why do you suppose they had to do that?" His question led to closer observation of the amount of shade being provided by the trees and to speculation about its effect on new growth.

Mr. Blake also brought to his teaching a wealth of scientific information that reflected his training in science. He was a storehouse of interesting facts that provided a rich contextual background to whatever was being discussed. Factual information was also considered important.

> What is it you want them to know, anyway? They've got to have lots of these building blocks of knowledge before they start thinking about something else anyway. They have to have the language before they can talk. They have to have the words before they can speak the language.

Perhaps his belief that students must acquire information accounts for the fact that Mr. Blake sometimes did a lot of talking, explaining, and elaborating during science lessons. This frequently led the class to become teacher-centred and content-oriented and compromised his goal of a child-centred inquiry environment that he said he wanted to foster. Other pressures further compromised Mr. Blake's ideal for science teaching.

> I would like to approach science as being activity, but I'm not always able to do it. I guess it goes back to my organization. I have found that I have to strike a balance between what I think I should do and what I can do. I feel if I put everything into my teaching, what I believe in and feel that I should do, I couldn't do it all. It affects science because I don't plan as much, I don't organize as much as I would like to do. I have to make compromises. The compromises I make are having a lot of lecture-type lessons rather than activities.

Even this exceptional teacher was faced with compromises and trade-offs in his science teaching, and his goal of achieving a child-centred inquiry environment remained elusive.

For the other teachers, other factors compromised their teaching of science and affected the status of science in the curriculum. Limited interest in and attention to science at all administrative levels and from the community, teachers' lack of confidence in their ability to understand science adequately and to teach it effectively, their poor science backgrounds, crowded timetables, preoccupation with the "basics," and lack of science materials all contributed to the current state of science teaching at Seaward School. The fact that no one insisted on science being taught regularly and according to provincial guidelines further confirmed its low status on the "importance scale." Evidence that science continues to be considered peripheral to the school program was demonstrated during my last visit to the school, several months ago. In a discussion with the new principal and vice-principal, the latter suggested that perhaps the best solution to the "science problem" would be to eliminate it from the curriculum until grade 4. I doubt this will actually happen. Rather, I suspect science will continue on in much the same manner as it has over the years.

Science at Trillium Public School

We turn now to Russell's study of science teaching at Trillium Public School, which serves children from kindergarten through grade eight. Russell examined science teaching through grade six, and his colleague, John Olson, attended to science teaching in grades seven and eight. Olson's findings are reported separately in his paper, "Mr. Swift and the Clock: Understanding Teacher Influence in the Science Classroom."

Arrangements for the study of science teaching at Trillium Public School did not include access to or discussion with the entire staff of the school. Instead, the vice-principal, Mr. Swift, approached and obtained the agreement of two teachers who were thought likely to be willing to open their teaching of science to the eyes and questions of an outsider. The result is that I worked with those two teachers (between kindergarten and grade six) most confident about the teaching of science. The work of these two teachers provides interesting contrast to the general points established in the study of science teaching at Seaward School.

At the K-6 level in schools in Ontario, science and social studies are treated under the combined heading, "social and environmental studies," or "S.E.S." This is noteworthy in its own right because it could enable a teacher to devote the necessary time to S.E.S. without including very much or any science. This was not the case, however, with either Mrs. Macdonald, who teaches grade three, or Mr. Clark, who teaches grade five.

Mrs. Macdonald

When asked to describe what had happened in the science area of the curriculum in the first part of the school year, Mrs. Macdonald replied very straightforwardly, "Not as much as I'd like." Short units on plants and "the universe" preceded discussion of living things in general, eventually resulting in a "decision" to study mammals in greater detail. This led to a focus on the tundra area of the Canadian North, because Canada is an S.E.S. focus in grade three and because the animals of the tundra tend to be mammals. Mrs. Macdonald's teaching philosophy and experience are evident in her further explanation that the mammals of the tundra are not those of the children's everyday experience. The differences would provide a basis for comparison, and the children would not "get hung up doing a unit on the cat or the dog."

When we discussed the units recommended by her Board of Education for grade three, Mrs. Macdonald explained that quite a bit of material is provided for teachers, but not so much to be used as printed as to serve as a set of starting points. For example, she expected to integrate the content of the two physical science units designated as grade three into the unit on the tundra and Canadian North. Mrs. Macdonald's ability to practice the integration she believes in confirmed that she is fairly comfortable with science topics. She explained that she was offered a position teaching science at the grade 8 level in another county when she completed her preservice teacher education, but she decided against that position in favour of working nearer home. Mrs. Macdonald believes that she does not include enough science in her program, that she could do more, and that science is not included to an adequate degree in the elementary grades, particularly kindergarten to grade three. In Mrs. Macdonald's view, her county has worked very hard to incorporate the concepts of The Formative Years (the official Ontario curriculum document for K-6) into its school programs. We could only speculate as to why separate science units have been developed, rather than units that integrate Social and Environmental Studies.

The concept of integration in teaching at the elementary level was obviously facilitated by Mrs. Macdonald's ability to relate content areas to each other. She rarely used a curriculum document as it is printed. When teaching grade 4, several years ago, she never used the official unit on "Water." Instead, Mrs. Macdonald "used water as the vehicle for teaching the whole S.E.S. program." After studying the local water system, they studied reclaimed lands in Europe. The Nile River system in Egypt served as an ancient community, and the formation of Hawaii by volcanic action provided water-related study of a "new-found land." "One could almost go around the world using water."

Related features of Mrs. Macdonald's teaching were her sensitivity to children's interests and her responsiveness to items children bring to school. The classroom had one fish tank, which had most recently served to demonstrate the "pollution" that results from overfeeding the fish. In a previous year, when the children were "super keen" about the live fish, four tanks were used, many species were bred successfully, and these activities served as a focal point for work in family studies. (All such activities are both demanding and risky; one winter weekend the heat failed in the school and only the fish in the largest tank survived.) Plants lined the window sills in Mrs. Macdonald's classroom, adding interest but also providing a ready

source of material for studying plant propagation. Mrs. Macdonald attempted to "facilitate" unexpected events that display teaching potential. When a boy brought a young snake to school, Mrs. Macdonald had time to prepare some worksheets for the children before they returned from lunch. "You just throw out your afternoon's work and go at it in a different way." The children practiced measurement, estimation, and looking for detail; then they drew the snake twice, in an attempt to get the most accurate colours.

Perhaps the pre-university high school program does permit an exclusive attention to the content of teaching subjects, including the sciences. Mrs. Macdonald's work in grade three made it apparent that there are many other considerations. Because no one set of facts seems essential, themes can be developed and integration of subject areas attempted. Mrs. Macdonald tried to build on children's interests, but she balanced what they "want" to do against her own sense of her responsibilities as a teacher of young children. Thus when 75 per cent of the children declared an interest in mammals, their topic became "mammals of the tundra," to ensure that the children would be challenged by the unfamiliar. Many children were eager to have a "pet day" when they could bring their pets to school, but there were six asthmatic children in the class, so pet day would wait until warmer weather when children and pets could meet outside. The presence in the class of a significant number of children who required almost constant "surveillance" was an obvious constraint on arrangements of children for working purposes, and Mrs. Macdonald's customary use of groups had been delayed and reduced that year.

Mr. Clark

No "formal" science experiments were observed at the grade three level, but they were readily apparent in Mr. Clark's grade five classroom. Mr. Clark quickly replied, "No, not at all," to my asking whether science is "pushed" at Trillium Public School. He said this realistically, not negatively, and he cited two facts in support of his conclusion. One was the fact that Trillium School does have a "Science Room," with facilities and equipment uniquely suited to the teaching of science. However, the Science Room was largely unavailable to any but the students in grades seven and eight. This derived from the fact that attempts to take his own students into the Science Room were met by responses indicating that this would be inconvenient for the people regularly using the room and that area of the school. The second was the fact that no one in the school has been designated as "the science teacher," with responsibility for supporting

science in every classroom. This role could fall to Mr. Swift, as teacher of science to grades seven and eight, but Mr. Swift has not adopted such a stance. Mr. Clark described Trillium Public School as very traditional and very comfortable, and one characteristic this implied was that a teacher did not move outside his or her present role. Mr. Clark did make an effort to have the entire school see the room in question as a Science Room for the school, without interfering with its use by grades seven and eight, but no one else responded to the opportunity and the idea died. Mr. Clark does all his in-school science teaching in his own classroom.

Mr. Clark expressed a personal view that most science teaching is and should be incidental, with everything depending on proper timing. For example, when the space shuttle was first launched, he devoted the entire day to that topic and related matters, building on children's keen interest. When water pollution became a topic in the local newspaper over a period of several weeks, he made that his topic for science. Mr. Clark also stressed his personal view that on complex and controversial topics a teacher must remain "completely unbiased," working strenuously and continuously to avoid being on either side of a value question. For example, when explaining the "bad" features of water pollution, he also points out that when wastes already exist, something has to be done and compromises made. Real problems cannot be ignored. Mr. Clark saw his role with grade five children as one of giving them the facts and letting them decide for themselves on matters of controversy. This general posture was one that Mr. Clark maintained throughout Social and Environmental Studies, recognizing that the line dividing the two is sometimes blurred.

Logical thinking and organization were two of the major themes of Mr. Clark's work with his grade five class. He hoped that, by the end of the year, most children would be better able to organize their thoughts, to sort out what is important, and to recognize what to accept and when to listen. At this age they already knew many facts, and he strived to arouse their curiosity, to lead them to new questions, and to have them apply what they already knew. For example, he hoped to get away from statements like "That's a robin," and move on to questions like "How and why can a robin fly?"

My observations of science teaching by Mr. Clark took place during a unit on Air. Science was taught within the Social and

Environmental Studies periods that were scheduled into the school's six-day cycle. A total of 300 minutes was allocated to S.E.S. over each six-day cycle, for a daily average of 50 minutes. Every other day there was an S.E.S. allocation of 60 minutes, between afternoon recess and the end of the school day. These periods were agreed to be the most suitable for observation.

On my first visit, the children returning to the classroom from afternoon recess immediately noticed the "apparatus" hanging from the ceiling at the front of the room, directly in front of the chalkboard. Two tetherballs were suspended by string from opposite ends of a metre stick, and the stick itself was supported by a piece of string at its midpoint. A piece of plasticine at one end of the metre stick served to balance the stick in a horizontal position.

Science teachers will quickly recognize that this apparatus is intended to provide data relevant to the issue of whether air can be shown to have mass. This was also readily apparent to the children, but the dialogue that occurred in this introductory phase of the activity illustrated something of the nature of discussion of science topics at the grade five level.

Mr. Clark	Students
What on each side gives it the mass?	Air
What else must balance?	The stick across
	How much the string is
There's something else you forgot . . . the weight, the mass of . . .	The weight of the tetherball
And the mass of the plasticine	

At this point, Mr. Clark pointed out that he had also taped an inflating needle to each ball, since a needle must be inserted to permit air to escape from one ball. He then used another metre stick to demonstrate visibly the effect on the stick of changing the mass attached to either end. As the discussion proceeded, Mr. Clark alternated between the terms "weight" and "mass," on some occasions correcting "weight" to "mass." The children seemed to use the term "weight."

Mr. Clark	Students
If I were to remove the air from one, what would happen?	It'll go off balance
Which way would it go? . . . Think about it for a minute	(Children indicate their personal opinions)
Most of you seem to agree it will go up. What would that mean, or prove?	Air has weight

Mr. Clark wrote "Air has weight" on the board and then inserted a needle to permit air to escape from one of the tetherballs. No obvious change could be observed in the position of the metre stick, and the children concluded that its position was unchanged.

Mr. Clark	Students
Would you agree that air has weight?	Yes
But it's a very small weight	

This discussion took about 15 minutes. For the next 20 minutes, the children performed a similar experiment after an explanation by Mr. Clark. By inserting a pin through a plastic straw and into the end of a ruler held to the desk by a book, the children could attach an inflated balloon to one end of the straw and balance the mass of the balloon with a tiny piece of plasticine at the other end of the straw. They were then asked to observe what happened to the position of the straw when they used a pin to puncture the balloon, inserting the pin near the neck of the balloon to avoid having the balloon break into pieces. With great enthusiasm, and an impressive degree of orderliness, the children proceeded to create every imaginable variation on the general theme. I was called upon to tie knots in balloons and to insert pins into the ends of rulers; I was also called upon to assist in interpreting the widely varying results. Several pairs of children managed to create a slow leak in a balloon, enabling them to see the straw tilt more and more as the balloon shrank in size.

Twenty minutes after the experiments began, the children were busy cleaning up and the room looked just as it had before.

After a brief discussion of the results and a short demonstration by Mr. Clark, the children were asked to take out their S.E.S. notebooks and begin their write-up. The following material was written on the board for the children to copy, before drawing a diagram to show the apparatus used.

ACTIVITY IV

Purpose: To see if air has weight.
Apparatus:

The children were offered a choice of drawing the tetherballs or the soda-straw balance, and roughly equal numbers seemed to choose each. The class worked quietly until the bell rang, and normal end-of-school activities were followed by dismissal.

A few days later, another lesson in the same unit on Air again presented the pattern of simple demonstrations accompanied by discussion, questions to the children, and written work by the children in their exercise books. During the lesson I was impressed by the preparation time required to ensure that demonstrations could and would work. Science demonstrations also require a confidence that things will work, and a readiness to go looking for extra equipment.

Issues in Elementary Science Teaching

The variety of issues introduced in Schoeneberger's discussion of science teaching at Seaward School are given detail and contrast by Russell's presentation of the thoughts and activities of two teachers at Trillium Public School. We conclude with discussion of a number of inter-related issues, drawing on evidence from each of the two schools.

The school curriculum

At Seaward, a specific curriculum package is prescribed for use by all the teachers, providing the potential for a coherent development of skills and ideas over the elementary years. In practice, the STEM requirement that locally-available materials be used acts as a deterrent to many of the teachers. At Trillium, locally-developed science units call for particular topics in biological and physical science to be taught in each year from kindergarten to grade six. The units serve as starting points for experienced teachers, and as reference points for beginning teachers. Clearly, each approach has advantages and disadvantages, and the individual teacher determines the amount of science actually taught.

Personal confidence

In each of the two schools, we worked most closely with teachers who exhibited significant confidence with respect to teaching science. Personal confidence develops in a variety of ways. Mr. Blake majored in biology in his work as an undergraduate. Mr. Clark and Mrs. Macdonald developed their confidence through experience, assisted by occasional participation in workshops and curriculum-writing teams. One important step in building confidence is the willingness to assemble and maintain collections of science-related materials. When personal confidence is lacking, as was the case for many teachers at Seaward, this can be a significant deterrent to teaching science.

Availability of equipment

At Seaward, much of the equipment that was available within the school did not match the requirements of the curriculum materials, and no procedures had been developed to assist teachers in obtaining the simple materials that were called for. It was up to individual teachers to gather what they needed, and with the exception of Mr. Blake, most teachers did not make the effort. At Trillium, the equipment in the Science Room was reserved for use by students in grades seven and eight. This gave Mr. Swift the assurance that the equipment he needed to teach science would always be available and in good condition. Mr. Clark and Mrs. Macdonald have assembled personal collections of equipment relevant to the topics they teach each year. Mr. Clark has developed a knack for simple demonstrations and student activities. He maintains a "private stock" of the cans once used to supply duplicating fluid, and each year one or two are consumed in the "collapsing can" demonstration that is intended to show that air exerts pressure.

Within-school communication

Our data from these two schools suggest that there is little value in the idea of special science training for one teacher in a school, for later dissemination to colleagues. Science seems particularly prone to the "expert/non-expert" contrast, which can serve to block communication. The teachers at Seaward were unable, by and large, to draw upon Mr. Blake's knowledge and skills in science, even though it was known that he was willing to provide assistance in terms of workshops, materials, and ideas. At Trillium, Mr. Swift divided his time equally between the duties of vice-principal and the teaching of science to all students in grades seven and eight. Despite this high profile in science, he did not elect to assume responsibility for monitoring or facilitating the teaching of science in kindergarten through

grade six. To do so would have required both time and diplomacy, and it is not inconceivable that it would have interfered with his responsibilities as vice-principal.

Integration

At Seaward, "integration" proved to be a convenient term by which some teachers, particularly in the lower grades, could claim to be teaching science for the specified ten per cent allotment, when in fact they were referring to occasions when science-related topics arise in other areas of the school curriculum. Mrs. Macdonald at Trillium and Mr. Blake at Seaward provide the contrasting cases of teachers who use integration out of a genuine conviction of its value as a teaching principle appropriate to children in the elementary years. We conclude that the meaning of a term so broad as integration may only be judged accurately through observation and interview with individual teachers. The idea of integration has distinct potential, yet it is a challenge because it is unfamiliar to many and because it is open to so many uses and interpretations.

Time constraints

Particularly in the years of kindergarten through grade three, the unique importance of developing skills in reading, writing, and arithmetic presents the real possibility that a subject like science, with its ten per cent time allotment and its "mystique" within our culture, will be viewed as "a little added frill." Time ranks with equipment and personal confidence as factors that determine in significant ways just how much attention science will receive at the hands of a particular teacher. If science could be seen as an integral part of the development of each child's school-related skills, it might receive a greater portion of the available time. Mrs. Macdonald's experience shows that an unusually high number of children with "special needs" can also interfere with the teaching of science. In this instance, the introduction of group work as part of a strategy of teaching by integration had to be delayed until later in the year.

Girls and science

At both Trillium and Seaward we were aware that teachers are increasingly aware of, but no closer to resolving, the dilemma that boys are easily seen as more interested and competent than girls when science topics are taught. Mr. Clark realized that some of the wall displays in his classroom could be interpreted by parents as closer to the interests of boys than of girls. Although he felt this was not a problem for the children he taught, Mr. Clark was careful to ensure that displays of

materials satisfying both stereotypes were in evidence on parents' nights. Mr. Blake had obtained one of the school's two microcomputers for full-time use in his classroom, and the boys were much more attracted to it than the girls. Over time he learned that some of the girls had been cautioned by their parents to avoid the computer, lest they break it. The notion that girls are less competent with respect to specialized equipment was alive and well in the minds of the parents. Although Mr. Blake had resolved that the sub-group of boys with special interests in science and computers would not be denied the benefits of his expertise, he had no special plans for cultivating in girls a greater interest in computers or science.

Importance of science

The Seaward situation raises the issue of the perceived importance of science at the elementary level. Apparently, it was acceptable practice for individual teachers to decide how much attention, if any, would be given to science in the class timetable. The state of science at the school was well known at all administrative levels, yet little was done to change things in any appreciable way, even to the extent of requiring that it be taught at least ten per cent of the time. (Even the ten per cent figure may be threatened. A recent document from the Ontario Ministry of Education sets the minimum time allotment for science in grades 7 and 8 at only eight per cent.)

It is interesting to speculate about the fate of any teacher who would quite openly admit, year after year, that she or he knew little about language arts or mathematics (and did little about it) and, furthermore, taught it irregularly. What would be the reaction of school, district, and Ministry officials and the community? Yet this is often the case with science, even though it is regarded by the Ministry of Education as one of the core subjects in the elementary program. Does the perception of science throughout the educational system reflect a scientifically illiterate population in general?

These are the major issues and factors that we identified as we studied the teaching of science in two elementary schools. The issues are familiar, long-standing, and problematic. These case-study analyses of individual schools and teachers point up the limited value of sweeping generalizations about how problems related to the teaching of science should be interpreted or resolved. "Add a little frill" goes a long way toward summarizing the status of science teaching in the elementary schools we studied.